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Index Insurance for Forage, Pasture, and Rangeland: A Review of Developed (USA and Canada) and Developing (Kenya and Ethiopia) Countries

Simon Maina [1,2], Maryfrances Miller [2,*], Gregory L. Torell [2], Niall Hanan [3], Julius Anchang [3] and Njoki Kahiu [3]

1 Department of Economics, Applied Statistics & International Business, Las Cruces, NM 88003, USA; mksimon@nmsu.edu
2 Department of Agricultural Economics and Agricultural Business, New Mexico State University, Las Cruces, NM 88003, USA; gtorell@nmsu.edu
3 Plant and Environmental Sciences, New Mexico State University, Las Cruces, NM 88003, USA; nhanan@nmsu.edu (N.H.); anchang@nmsu.edu (J.A.); nkahiu@nmsu.edu (N.K.)
* Correspondence: franniem@nmsu.edu; Tel.: +1-(575)-646-2642

Abstract: Index insurance for forage, pasture, and rangeland has gained ground in policy and academic circles. Stakeholders promote it as an innovative risk management tool for enhancing resilience to drought-induced perils and providing a way for consumption smoothing to livestock producers in drought vulnerable ecosystems. Index insurance, which avoids market failures such as moral hazard, adverse selection, and transactional cost, has been piloted and implemented all over the world. To support future development and research on index-based insurance in livestock systems, operational index insurance for forage, pasture, and rangeland systems in developed (USA and Canada) and developing (Kenya and Ethiopia) countries are reviewed and compared. This paper finds some similar characteristics (huge subsidy payments—ranging from 50 to 100 percent, significant government role, low adoption, insufficient payouts, data challenges, etc.), of this product between the two regions. A major difference between the PRF and NDVI is the number of choices available to users of rainfall index insurance who face close to 3000 choice options, while NDVI users have less than 5 choice options available for them. Based on these insights, we highlight opportunities where the two regions can benchmark and improve upon their respective index insurance schemes—index-based livestock insurance (IBLI) in developing and rainfall index insurance for forage in developed regions.

Keywords: index; insurance; developing; developed; forage

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1. Introduction

Rangelands, otherwise known as grasslands, are a type of land in arid or semi-arid regions, consisting of indigenous vegetation, mostly grasses and shrubs and sometimes managed as natural ecosystems or as farmed ecosystems [1–3]. According to Prowse et al. [4], Havstad et al. [1], and Brunson et al. [5], the economic benefits of rangelands are numerous, and chief among these benefits is the fact that rangelands provide an important anchor for livestock-based food systems. Rangeland ecosystems also provide diverse and crucial global ecosystems services, one good example being their mitigation of climate change by serving as a carbon sink [6,7]. They (rangelands) also supply water and regulate its flow, alongside facilitating pollination [8,9]. Finally, rangelands are important in maintaining social and cultural values [1,10,11].

However, climate variability and long-term changes are eroding the capacity of rangelands to keep providing the above benefits. In Western U.S rangelands, occurrence of droughts, extreme temperatures, and wildfires have increased in the recent past [12], and this trend is projected to persist into the foreseeable future with even more devastating effects [13,14]. Similarly, droughts, elevated temperatures, and low precipitation are compromising the capacity of rangelands in Africa to provide livelihoods, threatening food security [15].

For livestock producers, years of prolonged drought impact grazing quality and the rate at which herds can replenish and replace lost animals [16–18]. Degraded rangelands tend to offer little economic value to pastoralists [19]. Livestock keepers inhabiting these rangelands face high uncertainty regarding the continuous capability of these rangelands to sustain their livelihoods [20,21]. Droughts disrupt *vegetation dynamics* (changes in vegetation structure and biogeography due to climate viability. Climate change alters an ecosystem's structure by disrupting the useful energy equilibrium, making rangeland management a complex endeavor [22]), as shown in Figure 1. As precipitation drops, this leads to insufficient forage yields, which can have major impacts on livestock systems resulting in economic losses. There is a consensus among economists, governments, and policy makers that the effects of climate change cannot be ameliorated or reduced through adaptation only. It may be necessary to combine the policy response with some form of indemnification [23]. Index-based insurance, which uses weather indicators such as rainfall or satellite-sensed greenness indices [24], is a tool used to mitigate some of these risks for livestock producers [7,25–27].

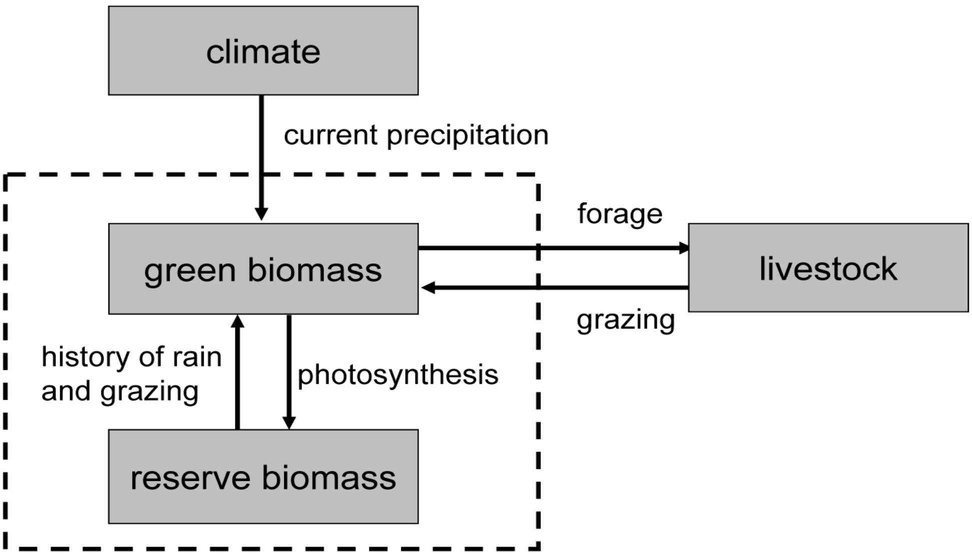

Figure 1. Vegetation dynamics. Source: adopted from Hrozencik and Perez-Quesada [28].

What Johnson [23] calls "*insurantial imaginaries* ("*Insurantial imaginary*" is the way in which, in a given economic, political, and social context, effective, efficient and profitable, and necessary uses can be found for insurance technology [23])" attached to index insurance in both developed and developing agricultural systems have proliferated in the recent past. Index-based insurance, which uses index (rainfall, greenness, temperature, etc. [29]) to determine payouts, is an evolving agricultural risk mitigation tool even in economically advanced regions of Western Europe and North America [7], and according to [30], index insurance in Africa is a "work in progress". This paper explores index insurance for forage, pasture, and rangelands by reviewing existing index-insurance schemes in North America and the Horn of Africa.

Numerous index insurance products have been developed, piloted, and in some cases implemented [31–33]. Since the inception of index insurance, researchers have been reviewing this product; for example, Adeyinka et al. [34] review index-based insurance on a global scale and in the purview of food insecurity and report that research on index-based livestock insurance is lacking in regions facing high climate and food security risks. On the same global scale, Clement et al. [35] undertake the review of the impact of basis risk on demand of index-based insurance. Other researchers, including Binswanger Mkhize [29], Hazell and Hess [36], and Tyagi and Joshi [37] evaluate the functionality of index insurance, and whether it is succeeding in mitigating agricultural risks. Di Marcantonio and Kayitakire [38] review pilot projects on index-based insurance for both crops and livestock in Africa and provide information regarding insights and lessons learned. Vroege at al. [7] review index-based insurance for grassland existing in two developed regions—North America and Europe. This article adds to the reviews by comparing index insurance in two geographical regions: North America, with its highly developed agricultural systems; and the Horn of Africa, and its developing agricultural systems. In both developed and developing economies, index-based insurance schemes are a new policy phenomena; therefore, no place can claim to have the most ideal and efficient index-based insurance product [39–41].

This review is organized as follows: in Section 2, this paper provides the methodology and the approach adopted in this review. In Section 3, general information about index-based insurance (IBI) is provided. Section 4 identifies and extracts key characteristics of forage, pasture, and rangelands insurance (FPRI) schemes in the two study regions and discusses the merits and demerits of the explored insurances. In Section 5, critical points identified in the two regional FPRI systems are compared, and then possible knowledge transfer and future possibilities are analyzed. Finally, in Section 6, conclusions are drawn, alongside discussing policy implications and the research agenda.

2. Methods, Approach Used and Literature Search

Index-based insurance for forage, pasture, and rangeland is a nascent practice in developing countries (Kenya and Ethiopia), while in developed countries (Canada and USA) it is a relatively established product [42]. The analysis is based on a systematic review of publications that touch on index-based insurance for forage, pasture, and rangelands in developed and developing regions in the span of 34 years (1990–2024). Using online sources such as *Google*, *Google Scholar*, *Scopus*, and *Science Direct* we considered publications on index-based insurance for forage, pasture, and rangelands, only written in English, and conducted in the USA and Canada for the developed region. This consideration extends to publications for the developing region where this review considers Kenya and Ethiopia. As the initial step, we performed a keyword(s) search in the online sources based on the two regions of interest. The search terms/keyword(s) used for developed countries (USA and Canada) included:

- *"Forage index insurance in the USA"*
- *"Index insurance for pasture + Canada"*
- *"Index insurance for pasture + USA"*
- *"Index insurance for rangelands in Canada"*
- *"Index insurance for rangelands in the USA"*
- *"Index insurance for prairies in North America"*

Search terms/keyword(s) for the developing region (Kenya and Ethiopia) included "index-based insurance in East Africa", "livestock insurance in Kenya", "livestock insurance in Ethiopia", and "index-based insurance in Kenya and Ethiopia". The two region searches generated 237 publications.

The search progressed further by conducting an iterative review of the references from the publications retrieved during the first search; the aim was to capture publications that may not have been detected by initial search terms/keyword(s). This procedure generated 29 additional publications: 3 for combined Kenya and Ethiopia, 11 and 7 for Kenya alone and Ethiopia only, respectively. Additional publications for Canada alone were 3, the USA received 2 additional publications. Finally, the remaining 3 publications combined information for both the USA and Canada. Finally, we had 266 (237 initial retrieved publications plus 29 iterative publications) publications to work with, which took the form of journals articles, reports, proceedings, policy papers, and master's and doctoral theses.

Publications that were considered irrelevant to this research objective were eliminated. Each material was checked, one by one, to align them (the publications) to the objectives of the review. Additionally, duplicates were discarded, and some publications were eliminated if they were considered "too shallow" in information required to meet the objective of the review. After completing the process of checking and sorting, 156 publications eventuated to in depth-review. This process of searching through in-depth review is shown in the form of a table, Table 1, and a flowchart in Figure 2. Figure 3 groups and links the papers with attention on the countries of focus.

Table 1. Exclusion criteria.

Category	Exclusion Criteria
Time	Studies not within 1990–2024
Relevance	Publications not addressing the topic: index insurance for forage, pasture, and rangeland
Shallowness	Publications considered as "too shallow" in terms of index insurance

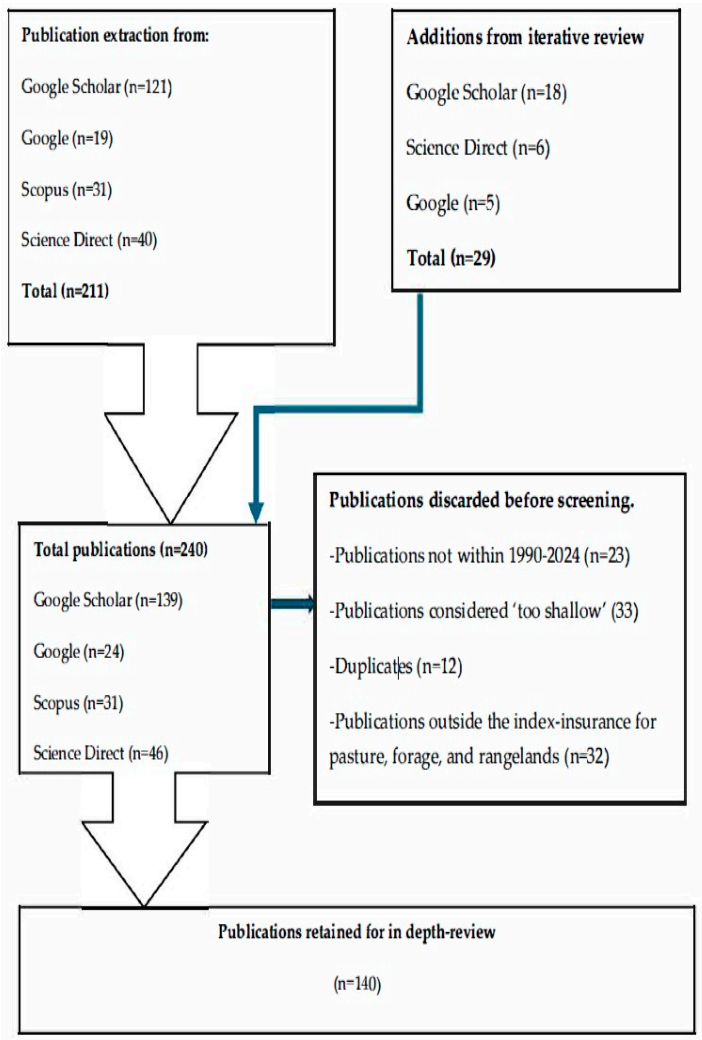

Figure 2. Flowchart of the article selection process.

United States and Canada

16, 17, 18, 27, 28, 31, 39, 70, 76, 75, 77, 78, 79, 80, 81, 82, 83, 94, 84, 85, 86, 87, 88, 90, 89, 95, 96, 91, 92, 93, 97, 99, 100, 101, 131, 132

African Countries

19, 23, 24, 25, 29, 30, 32, 38, 132, 49, 58, 60, 61, 62, 63, 64, 73, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 130, 138

Figure 3. Boxes (with hyperlinked numbers corresponding to citations) group publications within each focus region. Other papers reviewed focused on other regions, global relevance, theoretical, or economical discussions of agricultural insurance program.

Synthesis of Results

All the 156 articles dealt with some sort of information on designing index insurance. No single publication had conducted surveys in the USA and Canada. A significant number of publications on Kenya and Ethiopia had surveyed livestock producers as part of the research. About 67 publications had used “pasture” and “forage” interchangeably; and these publications were from both developed and developing regions. The term “basis risk” appeared in all 156 publications. The sections that follow provide reviewed information on index-based insurances of the developed and developing regions. Figure 3 shows distribution of publications by region.

3. Index-Based Insurance

It is believed that index (for the index to fulfill the quality standards of the insurance industry, it should be easy to observe and measure, objective, transparent, timely, and consistent [43]) insurance was first launched in developed countries (Western Europe and Northern America), before spreading to the rest of the world [44,45]. Unlike an indemnity insurance contract, where insurers pay compensation for “individual” losses [46–48], index insurance indemnifies policyholders based on easily observed values on a priorly identified and specified index; insurers configure payouts using environmental variables rather than direct loss inspection [23]. It takes an indirect route to matching payouts to losses. Typically, insurers determine payouts using an independent, measurable, and verifiable index [49,50]. Barnett [51] provides one of the popular definitions of index-based insurance; the author defines index-based insurance contract as simply basing the payouts on the value of an index rather than on actual individual loss experiences (idiosyncratic losses). Barnett expounds further by pointing out that the motivation to develop index-based insurance comes from the need to ameliorate and mitigate the challenges (such as high transactional cost and information asymmetry) that plague conventional/traditional insurance, which is especially important when measuring farm-level yield for some commodities (e.g., pasture and rangeland). In other words, index-based insurance (which utilizes scalar abstractions and geospatial technologies) is free of human manipulation [23]. Additionally, index insurance assists insurers to reduce biasness in contract design; the fact that an exogenous index, which relates strongly to covariate losses in a given locality, determines losses makes index insurance an independent, clear, and objective agricultural risks mitigation instrument [41–54]. The index approach to designing an agricultural risk management tool is effective in reducing two common sources of market failures: moral hazards (moral hazards are where a policy holder pursues actions or behaviors that increase the probability of loss occurring [55]) and adverse selection (in adverse selection, insurance purchasers select themselves based on risk exposure, those who perceive themselves as facing very high risk exposure are likely to purchase insurance cover [56]) [57]. The index approach also reduces transaction costs as it overcomes some of the administrative costs, such as “on farm” loss assessment [58]. Index-based livestock insurance has gained traction as one of the most effective agricultural risks management tools in both developed and developing countries. In agricultural activities, this product traces its inception to the 1970s [59].

In Africa, the inception of index insurance goes back to the early 2000s [60]. Since then, and more so in Sub-Saharan Africa (SSA), governments, insurance companies, non-governmental organizations (NGOs), and research institutions have been working together to develop and expand index insurance as an efficient tool in mitigating the effects of adverse weather-related catastrophes [61–64].

As an alternative to traditional indemnity-based insurance, the index-based insurance product started to emerge in the 1950s in the U.S. Over the last decade, this instrument based on a pre-defined index instead of individual losses has gained traction, especially in low-income nations [35,65]. Prior to experimenting with index insurance in grasslands, weather- and yield-based index insurances were in use in several countries such as the USA and Canada. However, their multiple shortcomings (lack of historical yields records [66] and the high cost of farm-level loss evaluation [67]) motivated policy makers and researchers to start experimenting with index-based insurance [68]. Despite its growing popularity, lack of clarity and consistency in loss indemnification plague index insurance contracts [23,27,32,40], resulting in low adoption rates.

Livestock producers are slow in taking up index insurance because of high basis risk [69]. "Basis risk" is the term given to the risk that is not captured by the index such as "design basis risk" [70–72]; when livestock producers perceive it as being extremely high [73], the possibility of signing up for the index insurance tends to be minimal. Vedenov and Miranda [69] explain that the three most popular types of basis risk that may discourage producers from signing up for the index insurance are as follows: (1) temporal basis risk (a mismatch of the index insurance contract and the stages of forage growth); the next one, (2) is the spatial basis risk (this basis risk is due to differentials in weather patterns across locations within the same region); lastly, (3) is the crop-specific basis risk, caused by the different ways crops vary in sensitivity to things like rainfall, planting times, etc.

Despite the shortcomings of index-based insurance, its continuous use will persist both in developed and developing nations because of its actuarial easiness of determining indemnities [74]. Currently, two types of indices are being utilized in different regions of the world: (1) area yield index insurance—which requires the historical yield data for the region being insured; and (2) the weather index insurance (WII) [51]. Table 2 provides advantages and disadvantages of both indemnity and index-based insurances.

Table 2. Advantages and disadvantages of indemnity and index insurances.

Insurance	Advantages	Disadvantages
Indemnity	Can cover multiple agricultural perils.	Within farms, assessment of losses makes it costly.
	Can be tailor-made to fit individual needs.	Ineffective in case of covariate losses.
Index insurance	Can overcome market failures such as adverse selection and moral hazards.	It does not consider individual insurance needs.
	Measuring index independently makes it transparent.	An index can have a weak correlation with loss sources resulting in insufficient payouts (basis risk).

4. Existing Index Insurance Regimes in Developed (USA and Canada) and Developing (Kenya and Ethiopia) Regions

4.1. FPRI-Developed Region (USA and Canada)

In America and Canada, index insurance has been an officially recognized risk management option (After the passing of the 1994 Crop Insurance Reform Act, the index insurance in the USA grew from generating under USD 1 billion in premiums in 1994 to generating close to USD 9.3 billion in 2016. USDA-RMA launched both rainfall index (RI) and vegetation index (VI) insurance pilot programs for pasture, rangeland, and forage (PRF) in 2007 in selected states. However, in 2016, vegetation index insurance was dropped in favor of rainfall index insurance. Thereafter, USDA-RMA launched the rainfall index insurance in all 48 states of the USA [75]. In addition, other researchers such as [75] have posited that index insurance for North America was first proposed in 1949) since the passing of the 1994 Crop Insurance Reform Act [76]. In the western United States, drought is one of the main risk factors in ranching. As a mitigation strategy against the impacts of droughts, the United States is experimenting with a variety of agricultural risks mitigation tools [18,77]; one of these tools, which the USDA-Risk Management Agency (RMA) has been testing since 2007, is rainfall index insurance for rangelands. In general, the insurers in rainfall index insurance base their insurance contracts on herders' geographical area rather than on an individual's definite location [16,78,79]. A livestock producer's role is to select whether to insure their grazing or haying acreage. Livestock producers also select their productivity factor, insurable interest and coverage levels. Finally, Cho and Brorsen [80] report that the presentation of this insurance cover is more of a group plan, with private companies executing the sale efforts and the federal government subsidizing the plan by more than half the price of the premiums. The hay or grazing land under consideration must not to be in the annual planting plan. Crucial steps taken by the livestock keepers leading to the actual signing of the insurance contract include determining the coverage level, index interval, protection factor, and the number of acreages; premiums are determined at the time of making the coverage decisions. To avoid overlaps, producers choose coverage based on the following monthly intervals:

a. April–June;
b. May–July;
c. June–August;
d. July–September;
e. August–October.

Livestock producers chose from the above options during the signing-up process with participating private insurance providers [81]. The list of qualified insurance providers operating in a particular location is usually with the Farm Service Agency (FSA) [82].

In 2016, this index insurance program spread to almost all of the U.S [83] and recently, the program has undergone some changes that include changing the index from a vegetative (NDVI) to a rainfall index in several states [80]. According to these authors, the "*Normalized Difference Vegetation Index*" (NDVI) (Remote sensed index insurance utilizes NDVI. NDVI is a satellite product that measure vegetation greenness, vigor, and health on the Earth's surface (ShalekBriski et al., 2021 [74]). NDVI can also be a measure of the amount of vegetation available for livestock [60]. On the other hand, rainfall index insurance uses gridded precipitation data from the National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA.CPC) to construct insurance for pasture, rangeland and forage [84]) data, which insurers obtain from the U.S. Geological Survey Earth Resources Observation and Science data center (EROS), has had some traction in South Dakota. However, Zhou et al. [85] posit that, starting from 2016, in the USA insurers have been switching from NDVI to rainfall index as they associate the former with larger basis risk than the latter.

The United States Department of Agriculture (USDA) Risk Management Agency has recently developed rainfall index for pasture, rangeland and forage (RI-PRF) insurance for livestock producers in the USA's rangelands [86]. For instance, rainfall variation in Utah creates the need for producers in Utah to make use of this insurance [87]; producers do not have to insure 100% of their acreage, annual forage crops are not eligible, and producers in Utah can only insure perennial pasture, rangeland, and forage crops, excluding irrigated alfalfa.

In 2009, index-based insurance for pasture, rangeland and forage (PRF) coverage was introduced in Nebraska and used satellite imagery to measure the "greenness" of pasture and hay lands for indemnity determination [87]. In the year 2009, about 750,000 acres of grazing and hay lands were covered, and participation rose to 2,500,000 acres in 2012. In the 2013 crop year, this insurance program switched from the NDVI to the rainfall index [88].

Although the rainfall index correlates more closely with production of forage than NDVI, making decisions on acreage, coverage level, protection factor, and index intervals tends to resemble a complicated labyrinth to most ranchers. Sometimes a rancher is presented with more than 214,400 different outcomes to choose from, making the process cumbersome and time-consuming [89]. ShalekBriski et al. [74] suggest improving the design of rainfall index insurance contracts, by reducing the number of interval and coverage level choices ranchers face at the sign-up. By doing this, these authors say it will help in mitigating the decision-making burden.

In 2014, RMA piloted rainfall index insurance for annual production of forage in Nebraska [90]. This insurance program targets both irrigated and non-irrigated acres of forage. The National Oceanic and Atmospheric Administration Climate Prediction Center (NOAACPC) provides the precipitation index that determines indemnity [17]. The sign-up is 15th of July and the acreage-reporting deadline is 15th of November for the coverage period that runs from 1st of September to 3rd of March. For season two, the sign-up deadline is 15th of December for a coverage period running from 1st of March to 30th of September and the acreage-reporting deadline for season two is July [90]. A unit area of insurance is divided into grids, and each grid identification (ID) is generated, later provided to producers by RMA via a link on their website. Each grid has an anticipated value, and a producer selects a coverage level between 70% and 90% of a grid's expected value.

4.1.1. Index and Grid

For a local area, the basis of coverage is on the rainfall index since forage production tends to vary closely with rainfall. This also means that the insurance coverage is a "single-peril coverage". The insurer pays indemnity when rainfall is not sufficient, and other causes of loss, such as fire, heat, disease, etc., are not included in the insurance coverage [91,92].

4.1.2. Grid Area, Dollar Coverage Levels, and Coverage Periods

The unit area of insurance is set according to grid areas; typical grid area ranges measures approximately 13 miles from east to west, and 17 miles from north to south [92]. NOAA utilizes daily rainfall measurements from the four closest reporting weather stations to a given grid area to determine the rainfall value for that grid; these grids are then accessible on the maps found on the RMA's website.

At sign-up, the parties involved match the plot of land to be insured to a particular grid area [93]. If a plot straddles a grid line, the insurance covers this plot as one unit in either one of the grids or in separate units by dividing it appropriately among the multiple grids in question. Each grid area has a base dollar value for grazing or haying, which RMA sets. Depending on what livestock producers select, as a productivity factor, this base dollar value adjusts upwards or downwards, usually from 60 to 150 percent. The producers also select the guaranteed coverage level, or the level at which payments trigger; producers may select coverage levels ranging from 70 to 90 percent—for example, a 70 percent coverage level triggers payouts whenever rainfall is below 70 percent of the historic average [80,92].

Producers then select the coverage period by selecting an index interval, which is a two-month period [83]; livestock producers must buy insurance cover for each parcel of land for at least two intervals (spread over four months). Rainfall index values are calculated using precipitation measurements over these two-month periods. After selecting the index intervals to insure, the producers then allocate the total dollar value of coverage across the selected intervals. For example, a particular producer may allocate 45 percent to the May–June interval and the remaining 55 percent to the September-October interval [91,92].

4.1.3. Premiums, Subsidies, Losses, and Indemnities

The producers are charged premiums, which are equivalent to the premium rate times the dollar coverage of the policy. Premium prices differ depending on the chosen index interval, since every index interval has its own dollar value, which reflects the variability of rainfall in each period. The RMA calculates premium subsidies using the percentage of dollar coverage [93]; for example, the federal government subsidizes up to 51 percent for 90 percent-dollar coverage and pays a 59 percent subsidy for 75 percent- and 70 percent-dollar coverage. Finally, insurers pay indemnities only when the rainfall index for the whole grid area falls short of the guaranteed level during an insured grid interval. The magnitude of the indemnity is the differential of the actual rainfall index and the selected guaranteed level [94]. Using information from Larsen and Anderson [90], Milhollin et al. [95], Jones et al. [96], and Feuz et al. [97], Table 3 provides the important building blocks of rainfall index insurance.

Table 3. Building blocks of rainfall index insurance.

Selection	Description
Crop type	Either haying or grazing
Grid IDs	Based on actual location
Coverage Level	70, 75, 80, 85, or 90 percent. Subsidy level is 59 percent for 70–75 percent coverage, 55 percent for 80–85 percent coverage, and 51 percent for 90 percent coverage.
Productivity Factor	60 to 150 percent of county base value in 1 percent increments
Index Intervals	Producers select the intervals when precipitation or plant growth is most critical to the producer.
Irrigated Practice	Irrigated or non-irrigated
Insured Acres	Total number of perennial haying and/or grazing acres. Insurance cover from any other insurance plan is prohibited for haying or grazing, by USDA programs.

According to Westerhold et al. [98], a contract of rainfall index insurance is a combination of the following four ratios/equations.

$$\text{Payment determinant} = \frac{\text{Trigger grid index} - \text{Final grid index}}{\text{Trigger grid index}} > 0 \tag{1}$$

$$\text{Policy unit} = \text{Insured acres} * \text{Producer share} * \text{Dollar amount of protection} \tag{2}$$

$$\text{Protection in Dollars} = \text{County base value} * \text{Productivity factor} * \text{Coverage level} \tag{3}$$

$$\text{Indemnity} = \text{Payment calculation factor} * \text{Policy protection per unit} \tag{4}$$

The above equations/ratios, plus the information provided in Table 1 above, are cumbersome for producers who are usually busy with production activities. Fortunately, the Risk Management Agency provides decision-supporting tools to aid livestock producers in determining their coverage. This RMA tool comes in four tabs, (1) the *grid locator*, which is essential for anyone enrolling to determine their grid ID, (2) historical indexes; this tab provides the historical percent of normal rainfall for each chosen grid ID. Livestock producers use other tabs, (3) and (4) to make decisions on the ideal coverage (tab 3) and to determine, beforehand, the indemnities (tab 4) they might receive in case of losses [90]. These tabs play an important role in helping livestock producers understand PRF policy design and have been contributing to a surge in enrollment over the last few years; however, there are still unresolved issues, such as questions regarding the optimal interval selection and the cumbersome choice load [78].

In Canada, there is a Multi-peril Crop Insurance (MPC), known as *AgriInsurance*, which is delivered by provincial-based crop insurance organizations in partnership with Agriculture and Agri-Food of the federal government of Canada [80]. Policyholders in this insurance program benefit from government subsidies; insurance purchasers pay 40% of the premium and federal and provincial governments pay the remaining 60 percent. The federal government also provides a reinsurance arrangement for the index insurance to provincial governments. Simpson [79] reports that the rainfall index insurance for forage was piloted in Ontario in the years 2000–2002, and later implemented in the province in the year 2005, subsequently expanding to other provinces such as Alberta, Saskatchewan, Manitoba, New Brunswick, and Nova Scotia. The index insurance utilizes a mix of indices; Manitoba, Saskatchewan, and British Columbia use measured yield. In Quebec, a simulated forage is used, Alberta uses a satellite-based index, while Nova Scotia and Ontario use a weather station-based index.

A good example of rainfall index insurance, given by Simpson [79], is that of the Ontario Forage Rainfall Plan which assists producers in managing both the risk of insufficient rainfall and of excess rainfall. In this insurance contract, no minimum farm size is required to sign-up; however, producers must meet a minimum coverage value. Insurers pay indemnity according to rainfall outcomes and use historical averages as the baseline. The coverage is restricted to the summer growing season and a professional weather service provides rainfall data. Lastly, to obtain this rainfall index insurance, producers choose rainfall thresholds and harvest periods and must specify the following:

- Coverage value: This is the dollar value for each forage stand, multiplied by the number of stands covered;
- Coverage level: To sign-up, producers have a choice of choosing a minimum of CAD 2000 or total forage crop value;
- Coverage alternative: Can either be the base plan, monthly weighting, bi-monthly, or three-month alternatives.

The base plan assumes that forage growth starts in May, and the first harvest is performed by the 1st of July. This is the most popular amongst producers. Since 2006, the base plan accounts for 49% of all the policies sold [99]. Basis risk is major problem, and just like in other parts of Canada, it impedes the uptake of index insurance. Wang [99] indicates that basis risk in Ontario may be due from the fact that the one index which determines payouts covers the entire province despite precipitation heterogeneity within the province.

Forage is particularly critical in the beef and dairy industry of Alberta and Saskatchewan [75]. Catastrophic risk, such as prolonged drought, can cause significant losses to producers. Fortunately, producers in these two provinces have access to index insurance where producers are required to choose the weather stations they think are most like their own farm's precipitation. In Alberta, producers have a choice between rainfall index-based and satellite index-based insurance, while in Saskatchewan, only rain index-based insurance is available for producers.

W. Vroege et al. [7] provide a nuanced profile of index insurance operating in the different provinces of Canada. In Alberta, these authors report that the Canadian Agriculture Financial Services Corporation offers coverage against rainfall deficit in any month a producer chooses. The authors show that in Ontario province, producers insure forage against drought (<85% normal precipitation) and can buy a ten-day cover during harvesting to insure against heavy (>5 mm or more) rainfall. In Saskatchewan, full season index insurance cover is available for livestock producers. Finally, W. Vroege et al. [7] report that livestock producers in provinces that have operational index insurance can select up to three weather stations at which insurers will be reading daily rainfall measurement. Additionally, T Frank [100] shows that the Alberta and Saskatchewan provinces represent a microcosm of index insurance in Canada; Table 4 provides the information about the two provinces' index insurance.

Table 4. Index insurance information for Alberta and Saskatchewan provinces.

Province	Program	Index	Temporal	Grid Size	Commencement Year
Alberta	Satellite	NDVI	Annual	1 km × 1 km	2001
Saskatchewan	Forage rainfall	Rainfall	April to July	Depends on weather stations	2001

Source: Adopted from T Frank [100].

Adoption of index insurance in both Canada and the USA appear to be sluggish; this is happening despite significant government support [101]. These authors give an example of ranchers in the Intermountain West area of the USA who express reservation regarding the RPF, claiming that sometimes there are no payouts during periods of low forage production. This claim runs contrary to what Hrozencik and Perez-Quesanda [28] report, finding evidence of rainfall index insurance enabling herders in the USA to restock after incurring losses from adverse weather.

Despite the effective innovation behind rainfall index insurance, adoption remains slow probably because of what producers face at the sign-up [18]. At the sign-up, producers face a decision that consists of complex combinations of multiple related coverage levels. This is corroborated by Davidson and Goodrich [39] who argue that under-enrollment to rainfall index insurance in the USA can be explained by the complexity of the choice structures ranchers face during enrollment. Williams [83] adds that the basis risk which insurers take as a major trade-off for the benefits that index-based insurance can provide, can impede the uptake of index insurance by herders. The author further reports that the main types of basis risks that can potentially hinder the index insurance uptake are the geographic and production basis risks. Geographic basis risk, this author says, is due to writing insurance contracts outside the location of livestock production, while the production basis risk has everything to do with plant phenology (phenology is the study of periodically recurring patterns of growth and development of plants [102] (p. 1923)). Notably, in the USA and Canada, the geographical basis risk can be reduced by interpolation (interpolation is the statistical augmentation of an index to reduce basis risk in index insurance [98]) techniques. In interpolation, data from nearby weather stations are used to estimate values in locations (within the same region) with no observation data. Williams [84] concludes by suggesting that NDVI insurance contracts tend to have higher basis risk than rainfall index-based insurance contracts and this makes stakeholders in index insurance for forage in North America (Canada and USA) drop NDVI in favor of rainfall index. Figure 4 indicates the rangelands in the developed region (USA and Canada) with index-based insurance for forage/pasture.

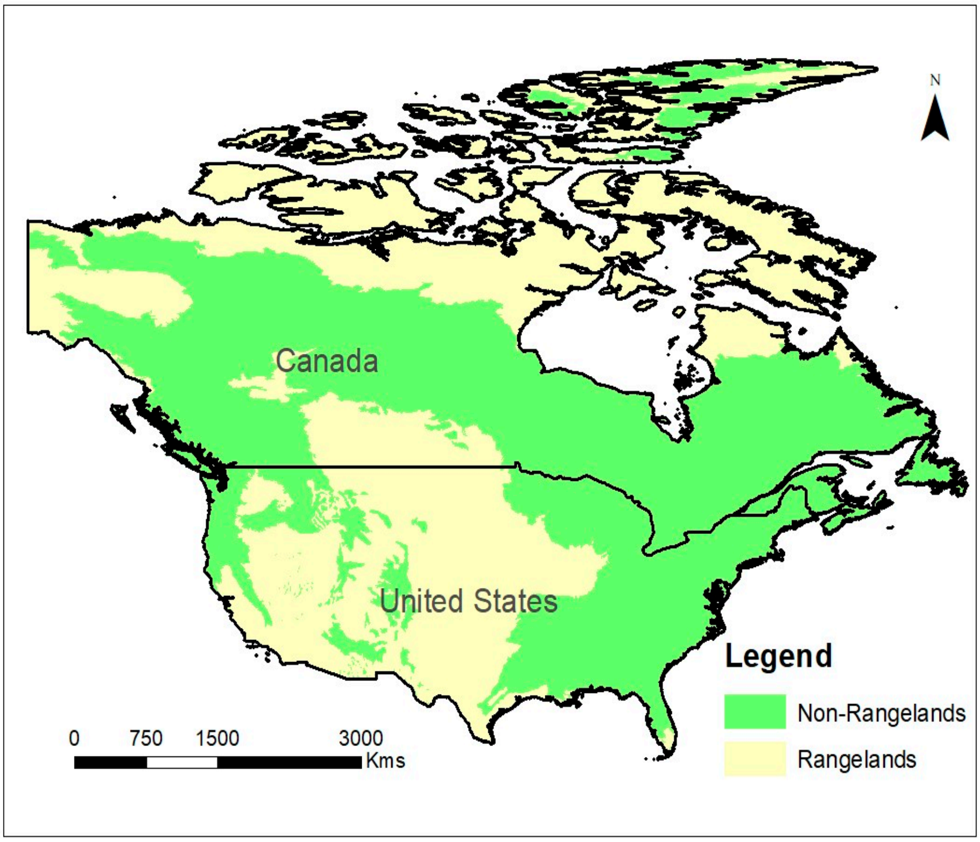

Figure 4. Rangelands with index-based insurance in the USA and Canada. Source: Adopted from Rangelands ATLAS [103] with modifications by the authors.

4.2. Index Insurance in Kenya and Ethiopia

While citing North America, we have shown some insights into how index-based insurance, as an agricultural risk management tool, works in developed countries. We now shift our focus to developing countries, by moving down to the Horn of Africa. Following [60], we undertake a review of index-based insurance for two countries in the Horn of Africa—Kenya and Ethiopia. We elect these two countries because, from the best of our knowledge, the index-based insurance piloting and implementation is comprehensive enough to provide a reasonable amount of information for review and discussion. In other words, just like [60] note, index-based insurance projects in Kenya and Ethiopia have passed the conceptualization and piloting stage; marketing, regulating, designing, and uptake are taking place.

The effects of weather variability on livestock systems tend to be similar everywhere, meaning that effects of climate change on the rangelands of the USA and its neighbor, Canada, may be the same on the rangelands of Kenya and Ethiopia [104,105]. Therefore, like agricultural systems in economically advanced regions, in many developing countries, livestock producers are plagued by a multitude of production risks; but the most pervasive are climate-induced risks [106]. Before the introduction of agricultural insurance, farmers often adopted risk avoidance, risk sharing, and risk diversification as strategies in risk management [54,106]. These strategies are inefficient and sometimes lead to unsustainable agricultural practices. Developing countries have always looked to developed countries for ways to develop profitable agricultural sectors; one thing that the developing countries have gained from developed countries is in the agricultural insurance market. Initially, some countries in the Horn of Africa adopted indemnity- (or conventional) based agricultural insurance, but it failed to gain momentum due to its inherent structural weakness. However, in recent times, Sub-Saharan Africa has adopted the index (in the past decades, Africa has been a beehive of activity with respect to index insurance feasibility studies and pilot projects, resulting in the launch and implementation of index-based insurance for forage in Kenya and Ethiopia [107,108])-based agricultural insurance.

The arid and semi-arid lands (ASALs) of northern Kenya and Southern Ethiopia experiences regular and severe droughts. For the last 100 years or more, in Kenya's arid and semi-arid lands (ASAL), which are home to more than three million pastoralist households, severe droughts have represented one of the major covariate losses; this is true even for Southern Ethiopia [29,30,109]. For instance, in 2013, of all the natural hazards that occurred in Sub–Saharan Africa, 50 percent were weather related [38]. These authors go on to say that Sub–Saharan Africa is hit by at least one drought in every 7.5 years. These droughts have a big impact on livestock systems, usually causing high livestock mortality, which erodes the welfare of pastoralist households who entirely depend on livestock for economic necessities [110–113]. Droughts also tend to induce poor farmers and pastoralists to adopt informal ex post strategies, which, the majority of the time, involve depleting productive assets to offset income shocks and smooth consumption [38]. To assist pastoralists and combat the weather-induced vagaries, the International Livestock Research Institute (ILRI), in corroboration with Cornell University and the University of California-Davis, came up with index-based livestock insurance (IBLI) as a risk management tool to insure pastoralists against drought-induced losses [38,60].

Starting with Northern Kenya, more than two million people occupy Northern Kenya's arid and semi-arid lands (ASALs) [114], and livestock keeping is the major source of livelihood. In cases of severe drought that cause high livestock mortality, a significant reduction in pastoralists' welfare occurs. It is imperative that the pastoralists maintain a critical herd size [114], reference Tropical Livestock Units (TLUs), and define a TLU as consisting of *one cattle*, *one camel*, and *ten goats or sheep*. To maintain or afford basic needs, a household should not own less than eight TLUs [114]. According to [115], during severe drought, the pastoralist experiences high livestock mortality, with the overall rainfall pattern in this ecosystem being as below.

1. October-December: short rain.
2. January-February: short, dry.
3. March-May: long rain.
4. June-September: long, dry.

In Kenya, the history of index-based insurance is relatively short, with the piloting and implementation of this insurance program happening in the northern part of the country in the early 2000s and involving multiple actors, such as the government and non-governmental organizations (NGOs), with the World Bank, local insurance companies, and agencies also contributing to these efforts. In 2015, the World Bank and the government of Kenya's (GOK) Livestock Insurance Program (KLIP), a macro-coverage scheme under the Ministry of Agriculture, Livestock, and Fisheries (MALF) picked up the lessons from IBLI and launched a similar but 100% subsidized insurance scheme in the northern Kenyan regions of Wajir, Turkana, Marsabit, and Mandera [61,116].

Ever since, index insurance has been promoted as a panacea to many of the weather-related bottle necks that are thought to impede the development and adoption of conventional insurance in Kenya and the entire African continent [32,117]. Using NDVI, insurers construct seasonal contracts covering long rain, long dry (LRLD), and short rain, short dry (SRSD) weather patterns. Then, the contract is made available to pastoralists two months prior to the start of a rainy season; assessment takes place at the end of a dry season to determine payouts [114,115]. Insurers in Kenya design much of index-based insurance with Muslim herders in mind, as most herders in northern Kenya relate more to the Islamic region; ignoring this religious aspect could impact the adoption and development of index insurance in the region [118,119]. Today index insurance in northern Kenya goes by the name index-based livestock insurance (IBLI) and it traces its commercial piloting and implementation back to the Marsabit region in January of 2010 [30].

According to Barnerjee et al. [120], multiple stakeholders/institutions play different roles in IBLI, with a Kenyan Commercial insurer, UAP Provincial Insurance Company Ltd., underwriting the IBLI's contract, and Equity bank, a private bank, distributing/brokering the IBLI's sales to pastoralists. The Swiss Reinsurance and International Livestock Research Institute (ILRI) supply international reinsurance services and research support, respectively. IBLI, which by construction evades the twin asymmetric information problems of adverse selection and moral hazards [121], undergoes one important step before becoming a ready-to-purchase insurance contract by the livestock keepers in northern Kenya and Southern Ethiopia. First, as Chantarat et al. [30] report, the NDVI data are set to standard to control for the heterogeneity of non-climatic factors across locations, this ensures that the cumulative vegetation status at the end of a season determines IBLI's regimes: good-vegetation year and bad-vegetation year regimes. Subsequently, these two regimes assist in establishing the empirical relationship between livestock mortality and the NDVI.

The delivery and distribution model of IBLI in the Horn of Africa is more of a community structure [116,122]. The insurance companies implement the marketing efforts of the product and distribute the insurance contracts through the local cooperative system; thereafter, insurance sales agents and the so-called village insurance promoters (VIP) pick up from there, to sign-up and educate pastoralists on the IBLI program [123,124].

The IBLI project has been hailed as a smart innovation that makes insurance commercially viable amongst poor livestock keepers in developing countries, including Kenya and Ethiopia [107,111,113]. In northern Kenya (Marsabit, Isiolo, and Wajir) and the Borena (the Borena zone in Southern Ethiopia is predominantly an arid area, with a total land area of about 95,000 square kilometers. To the northeast, its elevation ranges from 1000 m to 1600 m above sea level. Just like in northern Kenya, Borena experiences a bimodal type of precipitation (*April to May-long rain and October to November-long rain*) with an average annual rainfall ranging from 353 to 873 mm. Finally, the zone is home to approximately 400,000 people and keeps about one million animals, which include cattle, sheep, goats, and camels [125]) region of Southern Ethiopia, IBLI utilizes the NDVI—which has a high correlation with forage availability in these pastoral systems. According to Chantarat et al. [114], forage relates well to livestock deaths that occur in northern Kenya and southern Ethiopia (when severe droughts occur, forage availability diminishes, causing the death of animals). Other scholars posit that "IBLI leverages the strong correlation between a remotely sensed vegetation index and livestock losses associated with forage shortages" [126] (p. 1), to provide insurance to livestock keepers in the Horn of Africa. Ultimately, the NDVI index is the relationship between estimated herd mortality and forage availability. Table 5 shows information on when and where IBLI started in Kenya and Ethiopia.

Table 5. Year and month IBLI started in Kenya and Ethiopia.

Country	Region	Month	Year
Kenya	Marsabit	January	2010
Kenya	Isiolo	August	2013
Kenya	Wajir	August	2013
Kenya	Garissa	January	2015
Kenya	Mandera	January	2015
Ethiopia	Borena	July	2012

Source: Adopted from N.D. Jensen et al. [126].

In their report, Greatrex et al. [111] further show that pastoralists in northern Kenya choose the level of risk coverage based on trigger level. This trigger level can be either at 10 percent or at 15 percent. Regarding Ethiopia, in the same report, the authors indicate that the players in the index insurance of Ethiopia construct the contracts by utilizing the cumulative deviation from the normal condition of an area, aggregate NDVI data, and that payouts trigger when the deviation is below 15 percent. Finally, this report indicates that more women-headed than male-headed households purchase the index insurance cover, in both Kenya and Ethiopia, despite women not being actively involved in the index insurance information dissemination meetings. Figure 5 shows rangelands in Kenya and Ethiopia where IBLI operates.

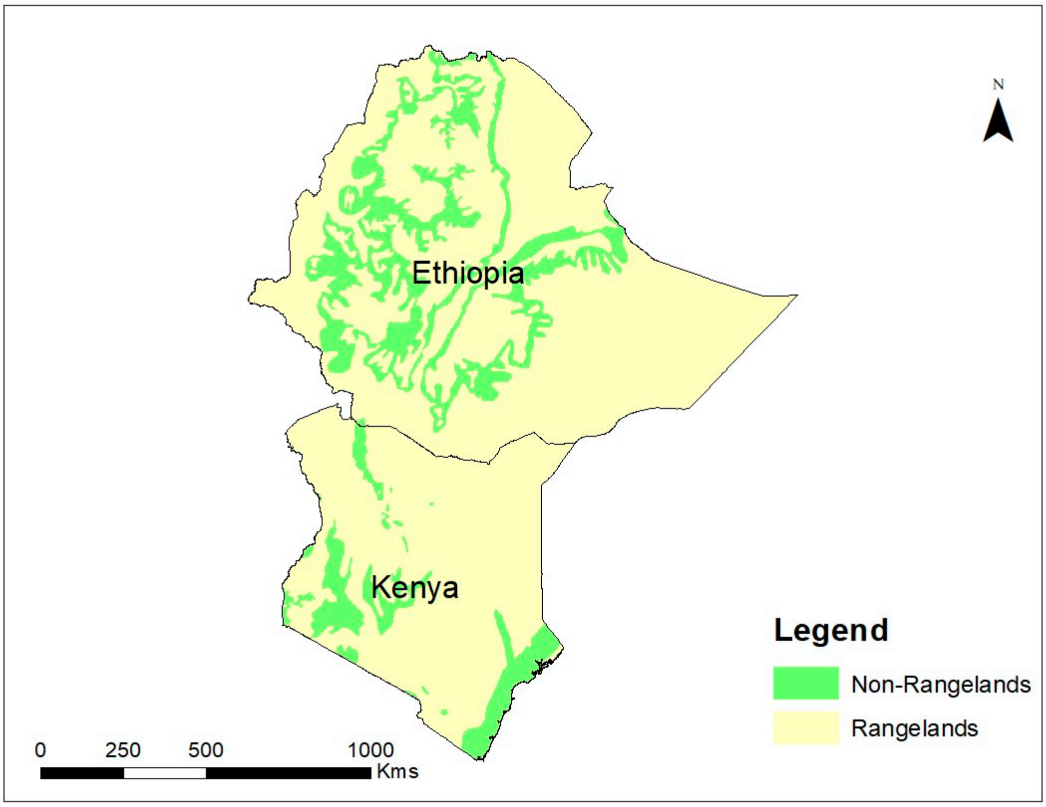

Figure 5. Rangelands in Kenya and Ethiopia with operational index-based livestock insurance. Source: Adopted from Rangelands ATLAS [103] with modifications by the authors.

5. Assessment of Two Regions' Index Insurance Regimes

We have explored index-based insurances for pasture, forage, and rangeland in economically advanced countries (USA and Canada) and developing counties (Kenya and Ethiopia). Despite the insurance launching in different times in the two regions, the motivation behind initiating this product is virtually similar. That is, to provide producers in pastoral systems with a risk management tool to combat climate change-induced vagaries which can potentially erode the capability of livestock systems to provide livelihoods to people who entirely depend on them [32,127,128]. Although the two regions differ significantly in political, social, and economic status, the benefits to livestock producers in the two regions that accrue from this insurance program are numerous. They range from giving the producers the incentive to venture into risky but profitable agricultural undertakings [90,126], to protecting pastoralists from falling into a poverty trap when a climate disaster strikes and completely erodes the key and critical herd base [114,117,129].

Index-based insurance coverage costs less than conventional/traditional insurance cover due to reduced underwriting costs since index-based insurance overcomes problems of informational asymmetry (adverse selection and moral hazard), and transaction costs [63]. Producers in both developed and developing regions can afford to buy this agricultural risk management tool. Compared to indemnity or conventional insurance, index-based insurance is an affordable derivative for producers all over the world, since cost-increasing market failures such as transaction costs, adverse selection, and moral hazards are avoided [130].

In both regions (developed and developing), the covariate phenomena of climate perils allow the forage, pasture, and rangeland index insurance providers to estimate losses and determine indemnity payments of a significant number of producers [45,61]. Producers/pastoralists and insurers in the USA, Canada, Kenya, and Ethiopia must face the biggest elephant in the index-based insurance room, which is "basis risk". According to Di Marcantonio [61], "basis risk makes index insurance intrinsically imperfect"; this author extends this argument by saying that a high level of homogeneity in insurance areas tends to reduce the basis risk. This means that product efficiency (one can define product efficiency, as used in index-based insurance, as the capability of a chosen index to capture the loss of the insured. That is, covariate loss = idiosyncratic loss [61,131]) is a work in progress in both developed and developing regions. Index insurance is mute with regards to market price-related risks [16,114]; this means that in the event of a weather catastrophe, livestock producers in the USA and Canada, and in Kenya and Ethiopia, can incur a double loss.

Governments, both at federal and state/province level in the USA and Canada, play a significant role in rolling out and subsidizing insurance [16,81,132]. This indicates the level of importance the authorities in the two countries attach to index insurance in terms of policy and implementation models; for example, the rate of subsidies given to livestock producers is well defined and backed by a clear policy. This is not the case in the Horn of Africa. Chelang'a et al. [131] and McPeak et al. [107] report a mosaic of players involved in IBLI (Kenya and Ethiopia) including the World Bank, NGOs, and research institutes such as the International Livestock Research Institute (ILRI). Di Marcantonio discusses the impact of subsidies in multiple countries, including a trial program in Kenya [61]. Here, a trial subsidy program for IBLI was enacted in some areas of Kenya, where the government of Kenya partnered with the World Bank to provide a 100% subsidized insurance to pastoralists in these areas.

There are also hosts of technical and implementation models to be learned from comparing the index insurance in these two regions. First, let us zoom in on property rights; Bentley and Oberhofer [82] (p. 54) say "property rights structures serve a series of economic and cultural objectives". This means that well-assigned property rights are imperative in agricultural development and economic growth. Additionally, establishing a clear property rights regime is critical in determining insurable interests [133–136]. Existing property rights regimes tend to affect the proper functioning of agricultural risk mitigation tools including index-based insurance. In communal rangelands, Bulte and Haagsma [137] show that despite buying index insurance cover, the benefits to pastoralists in northern Kenya and Southern Ethiopia rangelands may be limited because clear property rights do not exist; index insurance cover appears to incentivize the herders to pursue welfare de-enhancing behavior, such as overstocking beyond a socially optimal level. Property rights regimes governing rangelands in the USA and Canada tend to be properly established, institutionalized, and solidly enforced. Therefore, the livestock producers in this region do not have to face what Harding calls "the tragedy of the commons" (tragedy of the commons arises when it is impossible to exclude others from accessing a common-pool resource [138]). Poorly defined property rights may also pose a challenge to insurers in trying to establish "insurable interest" (the insurance interest doctrine plays a key role in the interpretation of the insurance contract. In its absence, the insurance contract would look like gambling and wagering [139] (p. 1)).

The pastoralists in northern Kenya and Southern Ethiopia can benefit a great deal if index insurance contracts can be designed based on property rights assigned to herding rangelands instead of the current communal lands. On the other hand, herders in the USA and Canada are usually faced with a huge and cumbersome choice load at the time of insurance sign-up. This challenge, which has been documented by Larsen and Anderson [86] and Walker [90] may impact the rate at which livestock producers sign up for the insurance. Index insurance stakeholders in the two countries (Canada and USA) may benefit by taking a leaf from the Horn of Africa and implementing a simplified insurance design. Moreover, index-based insurance regimes in Kenya and Ethiopia may benefit by replicating user-friendly online platforms, like the USA's RMA online platform. Finally, Kenyan and Ethiopian index insurance policy makers should think of a strategy to start utilizing the rainfall index or a combination of NDVI and the rainfall index, because in the USA, Jimenez Maldonado [18] shows that the rainfall index is associated with low basis risk when it is compared with NDVI.

6. Conclusions

We have discussed index-based insurance regimes in developed countries (USA and Canada) and developing countries (Kenya and Ethiopia). While the two regions are dramatically different, the philosophy and objective of index-based insurance regime for forage, pasture, and rangeland is similar in both regions. Which is, to mitigate the impacts of adverse weather conditions on livestock producers, enabling producers to smooth consumption when weather perils happen, and to purchase animal feeds during times of severe drought. Despite the same philosophy guiding the two regions' index insurance, there are some glaring variations between index insurance in the developed region (USA and Canada) and the one in the developing region (Kenya and Ethiopia). One such variation is in subsidies. The subsidy program regarding rainfall index insurance in the USA and Canada is clear and simple to understand. We suggest a similar policy regarding subsidy support of index-based insurance programs in Kenya and Ethiopia—this will be instrumental in assisting the herders in Kenya and Ethiopia to make decisions on insurance sign-up. Currently, the subsidy payment program is not clear, and both the magnitude of the subsidy and the mode of transmission are not very clear in Kenya and Ethiopia. Another important policy to pursue in Kenya and Ethiopia is in assigning property rights to the current communal lands. Even if pastoralists optimize their seasonal returns in open access rangelands, these communal rangelands still have an inherent problem of non-ownership. Pastoralists do not have a sense of ownership, and this limits their incentive to optimize the long-term pasture returns. Assigning and establishing a solid property rights regime in range management is imperative for enabling efficiency in most agricultural activities, including index insurance for forage and pasture. Policy makers, especially in the USA, should pursue a policy to reduce the index insurance choice load, currently plaguing livestock systems in this country. Finally, policy makers in Kenya and Ethiopia should pursue a policy that establishes an interactive online index insurance platform for the benefit of pastoralists in this region.

Regarding future research, scientists should adopt a multidisciplinary (economics, sociology, psychology, etc.) approach and look at how individual livestock producers perceive basis risk. Researchers should also look at a possible interaction between property rights and insurable interest. Further literature is also needed regarding a design of index-based insurance contracts that makes use of both NDVI and rainfall indices. Timu et al. [106] have documented gendered impacts of index-based insurance for developing countries' index-based livestock insurance (IBLI), but to the best of our knowledge, no similar research exists for economically advanced countries.

Another significant point is that in both regions, there are knowledge gaps that need to be sealed, possibly through sharing best practices from different locations or creating more knowledge through research. The final point is in regards to the basis risk, which is likely to be huge in the winter season in the cases of the USA and Canada, and during drought season in the cases of Kenya and Ethiopia. Since the inception of index-based insurance, basis risk has always been and still is *the elephant in the index-based insurance room*, and it continues to pose a big challenge to the adoptability and workability of index-based insurance for forage, pasture, and rangeland.

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